

Prevalence of Metabolic Syndrome in a Large Integrated Health Care System in North Carolina

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BACKGROUND Metabolic syndrome (MetS) is a cluster of conditions—including abdominal obesity, dyslipidemia, hypertension, and hyperglycemia—that are associated with a significantly increased risk of developing diabetes and cardiovascular diseases. No information currently exists regarding the prevalence of MetS in North Carolina. This study determined the prevalence of MetS among adults receiving care in a large integrated health care system in North Carolina.

METHODS This study used data from the Carolinas HealthCare System's electronic medical record system and included adults receiving care during 2014. The association between patient demographic characteristics and MetS was determined using multivariable logistic regression.

RESULTS The prevalence of MetS was approximately 22.5%. Individuals aged 18–29 years were less likely to have MetS compared with those aged 80 years and older (odds ratio [OR], 0.61; 95% confidence interval [CI], 0.56–0.67). Groups that were more likely to have MetS included women (OR, 1.07; 95% CI, 1.05–1.10), Hispanics (OR, 1.14; 95% CI, 1.05–1.23), individuals with Medicare (OR, 1.38; 95% CI, 1.33–1.42), and those with Medicaid (OR, 1.68; 95% CI, 1.58–1.78) compared with men, whites, and those with commercial insurance, respectively.

LIMITATIONS We excluded individuals with missing data for any of the conditions that define MetS, which may underestimate the actual prevalence of this condition.

CONCLUSIONS The considerable prevalence of MetS in our North Carolina sample suggests that interventions are needed to achieve the state's population health goals.

Metabolic syndrome (MetS) is defined by a group of related and co-occurring metabolic disorders—including abdominal obesity, dyslipidemia, hypertension, and hyperglycemia—all of which increase the risk of developing diabetes, cardiovascular disease, and stroke [1]. The common risk factors for MetS are physical inactivity, older age, minority race, family history of diabetes, history of gestational diabetes, history of nonalcoholic fatty liver disease, and polycystic ovary syndrome [2]. Compared to people without MetS, those with MetS are twice as likely to develop cardiovascular disease, 5 times more likely to develop diabetes, 2–4 times more likely to have a stroke, and 3–4 times more likely to develop myocardial infarction [1, 2]. The economic burden of MetS is also significant, with incremental annual medical costs being 60% higher for individuals with MetS than for those without this condition [3].

The prevalence of MetS in the United States has been well studied [4–11]. The majority of these analyses used data from the National Health and Nutrition Examination Survey (NHANES) [4, 6, 7, 9–11]. In the most recent research, which used the 2009–2010 NHANES data, Beltrán-Sánchez and colleagues reported the national prevalence of MetS to be 22.9%. In that study, the investigators also examined changes in the prevalence of MetS over the years, and they found that it had decreased slightly, from approximately

25.5% in 1999–2000 to 22.9% in 2009–2010 [11]. While these studies provide useful information, a major shortcoming of the NHANES data is that the survey design does not allow for regional estimates. With diet and exercise patterns varying across regions of the United States [12], it is likely that MetS prevalence also varies across regions.

Very few studies have determined the regional prevalence of MetS in the United States. Meigs and colleagues studied the prevalence of MetS among participants in the Framingham offspring study (FOS) and the San Antonio Heart Study (SAHS) and found age- and sex-adjusted prevalences of 24% among FOS participants, 21%–23% among white subjects in SAHS, and 30%–31% among Mexican-American subjects in SAHS [5]. In an analysis of patients in 12 outpatient health care practices in Massachusetts during 2003–2004, Hivert and colleagues found the prevalence of MetS to be 23% [8]. A thorough literature review revealed no such studies conducted in North Carolina.

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The objective of the current study was to determine the recent prevalence of MetS in a large, vertically integrated health care system in North Carolina. In addition, demographic variations in the prevalence of MetS were assessed.

Methods

Data Source

This cross-sectional study used 2014 data from the Carolinas HealthCare System's electronic medical record (EMR) system. Carolinas HealthCare System is the 2nd largest integrated nonprofit health care system in the United States, with more than 900 care locations—including hospitals, physician practices, destination centers, surgical and rehabilitation centers, home health agencies, nursing homes, and hospice and palliative care centers—in North Carolina, South Carolina, and Georgia. The Carolinas HealthCare System EMR system contains data from more than 10 million patient visits annually. Data fields within the Carolinas HealthCare System EMR system include self-reported patient demographic characteristics, including age, race/ethnicity, sex, marital status, and health insurance status; health care encounter data, including admission and discharge dates and times, diagnosis and procedure codes, and results of clinical tests; and inpatient and outpatient medication order data, including active ingredient, number of days of supply, dosage, brand name, and generic name. The study protocol was approved by the institutional review board of Carolinas HealthCare System.

Study Population

The study sample included adult patients (18 years and older) who had valid records for all 5 MetS measurements (body mass index [BMI], triglyceride levels, cholesterol levels, blood pressure, and blood glucose level) during 2014 and at least one health care visit (inpatient or outpatient) prior to documentation of their laboratory values in 2014. The sample was limited to patients receiving care at Carolinas HealthCare System's facilities in North Carolina. Extreme

outliers (individuals with lab values below the 0.25th percentile or above the 99.75th percentile) were excluded from the study because of the high possibility of inaccurate lab values in these individuals.

Measures

MetS was defined based on the diagnostic criteria developed by Hivert and colleagues (see Table 1). While health care organizations such as the National Cholesterol Education Program Adult Treatment Panel III and the American Heart Association have released diagnostic criteria to define MetS (abdominal obesity, elevated blood pressure, elevated fasting glucose, elevated fasting triglycerides, and low high-density lipoprotein cholesterol) [9], information for all of these criteria was not available for many patients in the Carolinas HealthCare System EMR system. Therefore, we used surrogate diagnostic criteria developed by Hivert and colleagues to define MetS. These criteria have been found to have sensitivity of 73%, specificity of 91%, and a c-statistic of 0.818 [8]. Using this definition, individuals were considered to have MetS if they satisfied at least 3 of the 5 criteria listed in Table 1 during the study year. If multiple measures were available for any of the criteria, the most recent measure was used.

The prevalence of MetS was defined as the ratio between the number of individuals with MetS and the total number of individuals included in the study. In addition to reporting the overall prevalence of MetS, we also reported the prevalence of individual criteria for MetS. Finally, we reported age-standardized MetS proportions, using the 2000 US Census population as the standard, in order to enable comparison of our results with those of previous studies.

The independent variables in the study were age, sex, race/ethnicity, and insurance status. Age was classified into 7 categories: 18–29 years, 30–39 years, 40–49 years, 50–59 years, 60–69 years, 70–79 years, and 80 years and older. Race/ethnicity consisted of 4 categories: white, African American, Hispanic, and other (consisting of

TABLE 1.
Criteria Used to Define Metabolic Syndrome

Metabolic syndrome criteria ^a	Formal NCEP-ATPIII characteristic	Surrogate characteristic
Central obesity	Waist circumference >102 cm (40 inches) in men or > 88 cm (35 inches) in women	Body mass index $\geq$ 29.1 kg/m ² in men or $\geq$ 27.2 kg/m ² in women; if height data are missing, then weight $\geq$ 94.4 kg (201 lbs) in men or $\geq$ 73.6 kg (162 lbs) in women
Elevated blood pressure	Average of last 2 readings $\geq$ 130 mmHg and/or $\geq$ 85 mmHg (systolic and diastolic, respectively); or diagnosis of hypertension on problem list and antihypertensive agent on medication list	Any of the following: 1 blood pressure $\geq$ 130 mmHg and/or $\geq$ 85 mmHg (systolic and diastolic, respectively); on antihypertensive medication but no diagnosis on problem list; or hypertension listed among billing codes
Elevated glucose levels	Fasting plasma glucose > 5.6 mmol/L (100 mg/dL)	Any plasma glucose $\geq$ 7.8 mmol/L (140 mg/dL)
Elevated triglyceride levels	Fasting plasma level $\geq$ 1.7 mmol/L (150 mg/dL)	Any plasma level $\geq$ 2.3 mmol/L (200 mg/dL)
Low high-density lipoprotein cholesterol level	Plasma level < 1.0 mmol/L (40 mg/dL) in men or < 1.3 mmol/L (50 mg/dL) in women	Plasma total cholesterol > 5.2 mmol/L (200 mg/dL)

^aIndividuals who satisfy 3 or more of the listed criteria were considered to have metabolic syndrome.

Note. NCEP-ATPIII, National Cholesterol Education Program Adult Treatment Panel III.

Source: Hivert MF, et al [8].

American Indians, Alaskan natives, Asians, Hawaiians, Pacific Islanders, and those with multiple or unknown races). Insurance status consisted of 4 categories: commercial, Medicare, Medicaid, and other (including patients receiving charity care, self-pay patients, or those whose insurance status was unknown). Insurance was categorized based on the patient's primary payer for the most recent health care visit prior to reporting of the laboratory values used to define MetS.

Statistical Analysis

The bivariate associations between MetS prevalence rates and the independent variables were determined using a chi-square test, and multivariable associations were determined using a logistic regression model. Frequencies and percentages are reported for the bivariate analyses, and odds ratios (ORs) are reported for the logistic regression model. All analyses were conducted using SAS version 9.4.

Results

The study sample consisted of 217,056 individuals, with an average age of 56.2 years (± 15.5 years). The majority of the sample was female (56.2%), white (72.9%), and insured by a commercial insurance policy (60.6%; see Table 2). A total of 48,786 individuals (22.5%) were classified as having MetS (see Figure 1). MetS prevalence was highest among those 50–59 years of age, females, Hispanics, and those with Medicaid insurance ($P < .001$; see Figures 1 and 2). Individual MetS criteria occurred at prevalences of 54.1% for high BMI, 60.9% for elevated blood pressure, 11.0% for elevated glucose levels, 15.3% for elevated triglyceride levels, and 29.9% for elevated cholesterol levels. Prevalences of individual criteria varied by age, sex, race, and type of insurance (see Table 3). The age-standardized MetS prevalence was 18.8%. It was highest among males, Hispanics, and those with Medicare (see Figure 2). The age-standardized prevalence estimates for the individual MetS criteria were 51.4% for high BMI, 49.5% for elevated blood pressure, 8.4% for elevated glucose levels, 13.7% for elevated triglyceride levels, and 28.7% for elevated cholesterol levels.

Table 4 presents the results of the multivariable logistic regression analysis conducted to determine how demographic characteristics impact MetS. Compared to individuals aged 80 years and older, the estimated odds of having MetS were 39% lower in individuals aged 18–29 years (OR, 0.61; 95% CI, 0.56–0.67; $P < .001$). Females had 7% higher estimated odds of having MetS compared to males (OR, 1.07; 95% CI, 1.05–1.10; $P < .001$), and Hispanics had 14% higher odds of having MetS compared to whites (OR, 1.14; 95% CI, 1.05–1.23; $P < .001$). Individuals with Medicare (OR, 1.38; 95% CI, 1.33–1.42; $P < .001$) or Medicaid (OR, 1.68; 95% CI, 1.58–1.78; $P < .001$) had 38% and 68% higher estimated odds, respectively, of having MetS compared to those with commercial insurance.

TABLE 2.
Study Sample Characteristics (N = 217,056)

Characteristic	n	%
Age (in years)		
18–29	12,331	5.7
30–39	22,243	10.2
40–49	39,344	18.1
50–59	50,651	23.3
60–69	50,074	23.1
70–79	30,104	13.9
≥ 80	12,309	5.7
Sex		
Female	121,895	56.2
Male	95,161	43.8
Race/ethnicity		
African American	36,533	16.8
Hispanic	3,439	1.6
Other ^a	18,917	8.7
White	158,167	72.9
Insurance status		
Medicare	76,127	35.1
Medicaid	5,846	2.7
Other ^b	3,590	1.7
Commercial	131,493	60.6

^aThe race/ethnicity category "other" includes American Indians, Alaskan natives, Asians, Hawaiians or Pacific Islanders, and those with multiple or unknown races.

^bThe insurance category "other" includes those receiving charity care, self-pay patients, and those whose insurance status is unknown.

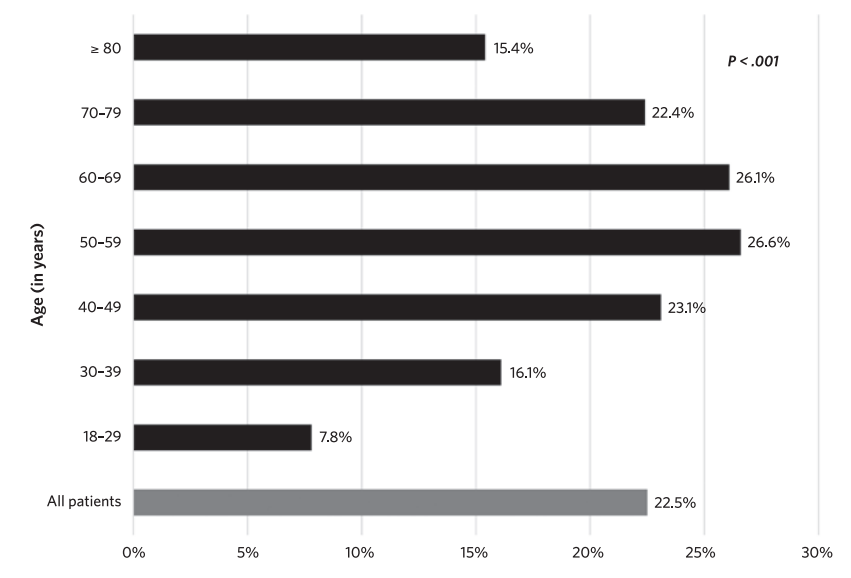
Discussion

The current study determined the prevalence of MetS in a large health care system in North Carolina and assessed the association between demographic characteristics and MetS. This study is one of very few to have investigated the prevalence of MetS for a specific region in the United States. Also, to the best of our knowledge, this is the first study determining the prevalence of MetS in North Carolina.

The crude prevalence of MetS was 22.5%. This finding is similar to the crude prevalence of 23% reported by Hivert and colleagues in their study of patients receiving care at 12 outpatient health care practices in Massachusetts during 2003–2004 [8]. However, we found an age-standardized prevalence of MetS of 18.8%, which was lower than the most recent national estimate of 22.9% based on the 2009–2010 NHANES data [11]. The likely reason for the lower age-standardized MetS prevalence in our study is the use of surrogate criteria for MetS, which have a sensitivity of 73% compared to the formal criteria for this condition.

In terms of individual criteria, the major factors contributing to MetS were elevated BMI (crude proportion of 54.1% and age-standardized proportion of 51.4%) and elevated blood pressure (crude proportion of 60.9% and age-standardized proportion of 49.5%). This finding is similar to that found by Hivert and colleagues in their study of patients in

FIGURE 1.
Crude Prevalence of Metabolic Syndrome in a Large Health Care System in North Carolina, by Patient Age, 2014



Massachusetts. However, in a study examining the national prevalence of MetS, Beltrán-Sánchez and colleagues found that increased waist circumference and elevated cholesterol levels were the criteria with the highest prevalence.

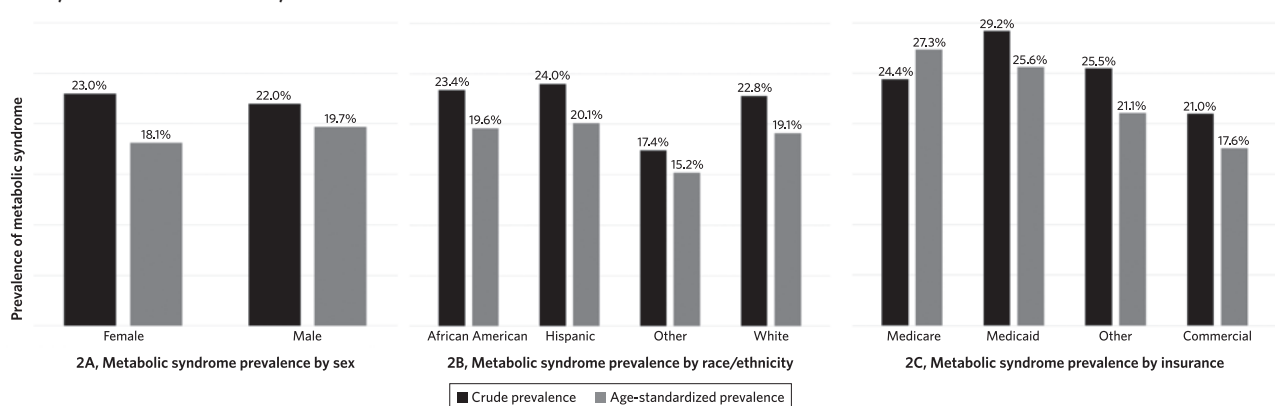
Interesting findings emerged from the logistic regression analysis conducted to examine the association between demographic factors and MetS. Patients aged 30-39 years and those aged 70-79 years were more likely to have MetS, and those aged 18-29 years were less likely to have MetS, compared to patients aged 80 years and older. MetS prevalence increased with age until the 6th decade and then decreased in the 7th and 8th decades of life. Increasing MetS prevalence with age has been reported in previous research [4, 8, 13]. The lower MetS prevalence among those in the

7th and 8th decades of life might be due to survival bias of individuals with better health in these age groups.

Women were 7% more likely to have MetS compared to men. The main criteria contributing to higher prevalence of MetS among women were elevated BMI (58.2% in women versus 49.0% in men) and elevated cholesterol levels (34.8% in women versus 23.6% in men). Factors such as weight gain after pregnancy, gestational diabetes mellitus, preeclampsia, polycystic ovary syndrome, use of hormonal contraceptives, and menopause increase the odds of females having MetS [14].

In terms of race and ethnicity, Hispanic individuals were 14% more likely to have MetS compared with non-Hispanic whites. This finding is consistent with previous research [4]

FIGURE 2.
Crude^a and Age-Standardized^b Prevalence of Metabolic Syndrome in a Large Health Care System in North Carolina, by Sex, Race, and Insurance Status, 2014



^aThe bivariate associations between crude metabolic syndrome prevalence and sex, race, and insurance status are statistically significant ($P < .001$).

^bAge-standardized prevalence estimates are based on the 2000 US Census population.

TABLE 3.
Prevalence of Individual Metabolic Syndrome Criteria in a Large Health Care System in North Carolina, 2014

Characteristic	Elevated BMI, %	P-value	Elevated blood pressure, %	P-value	Elevated glucose level, %	P-value	Elevated triglyceride level, %	P-value	Elevated cholesterol level, %	P-value
All patients	54.1		60.9		11.0		15.3		29.9	
Age (in years)		< .001		< .001		< .001		< .001		< .001
18–29	39.8		25.0		3.3		7.9		20.4	
30–39	52.2		36.5		5.1		13.1		29.8	
40–49	59.1		50.3		8.4		16.6		34.9	
50–59	59.4		62.0		11.4		17.1		36.4	
60–69	57.6		72.3		14.1		16.4		28.9	
70–79	49.3		78.9		15.1		14.8		22.3	
≥ 80	32.0		80.5		14.2		12.0		19.0	
Sex		< .001		< .001		< .001		< .001		< .001
Female	58.2		56.9		9.4		13.0		34.8	
Male	49.0		66.1		13.0		18.2		23.6	
Race/ethnicity		< .001		< .001		< .001		< .001		< .001
African American	67.6		68.7		12.9		7.7		27.1	
Hispanic	55.1		50.1		12.3		20.7		32.9	
Other ^a	44.0		48.5		7.9		13.8		33.5	
White	52.2		60.8		10.9		17.1		30.0	
Insurance status		< .001		< .001		< .001		< .001		< .001
Medicare	51.9		76.8		15.8		16.5		23.8	
Medicaid	66.2		61.8		16.5		21.3		26.7	
Other ^b	58.9		62.0		13.7		17.9		28.6	
Commercial	54.8		51.6		7.9		14.2		33.6	

^aThe race/ethnicity category “other” includes American Indians, Alaskan natives, Asians, Hawaiians or Pacific Islanders, and those with multiple or unknown races.

^bThe insurance category “other” includes those receiving charity care, self-pay patients, and those whose insurance status is unknown.

Note. BMI, body mass index.

and could be associated with the high prevalence of insulin resistance, the high prevalence of diabetes mellitus, and the propensity for elevated triglyceride levels in the Hispanic population [13].

In our study, patients with Medicaid and Medicare were more likely to have MetS compared with those who had commercial insurance. Previous work has shown that having less access to health care and limited family and community resources is associated with poorer health outcomes and more chronic health conditions in the Medicaid population [15, 16]; this trend was also seen in our study. Medicare beneficiaries include individuals above 65 years of age, individuals with disabilities, those with end-stage renal disease, and patients with amyotrophic lateral sclerosis. It is not surprising to see a higher prevalence of MetS in these individuals, as they have been found to have worse health status compared to those with private health insurance [17]. To the best of our knowledge, this is the first study determining the association between insurance status and MetS.

The findings of this study have important implications for health care providers and policy makers in North Carolina. Finding that 22.5% of patients in the largest health care system in North Carolina have MetS suggests that the burden of this condition in North Carolina could be significant. North Carolina is currently among the quartile of US states

with the highest prevalence proportions of diabetes and cardiovascular disease [18]. The Healthy North Carolina 2020 objectives include reducing diabetes prevalence and cardiovascular mortality rates [19]. Reducing the burden of MetS will be important for achieving these goals. Prior studies have found that MetS can be effectively managed with lifestyle interventions—such as counseling about diet modifications and physical exercise by family physicians, nurses, and dietitians, which target all the MetS components together—as well as pharmacological treatments targeting individual MetS components [20–22]. The associations observed in this study between demographic characteristics and MetS and its components could help policy makers in North Carolina to select targets for such interventions. The MetS prevalence estimates observed in this study could also be used as a baseline for judging the effectiveness of future interventions.

Issuing clear guidelines concerning the screening of patients for MetS would also further efforts to address the high prevalence of this condition. Japan has led the way in the development of such guidelines by recommending since 2008 that annual MetS screening be performed for individuals aged 40–74 years [23]. Currently, there are no specific guidelines regarding screening for MetS in clinical practice in the United States, and variations in the recommended

TABLE 4.
Estimated Odds of Metabolic Syndrome Among Adults
in a Large Health Care System in North Carolina, 2014

Characteristic	Odds ratio	95% CI	P-value
Age (in years)			
18-29	0.61	0.56-0.67	< .001
30-39	1.42	1.32-1.52	< .001
40-49	2.20	2.07-2.34	< .001
50-59	2.60	2.45-2.76	< .001
60-69	2.22	2.10-2.34	< .001
70-79	1.60	1.51-1.69	< .001
≥ 80	Reference		
Sex			
Female	1.07	1.05-1.10	< .001
Male	Reference		
Race/ethnicity			
African American	1.01	0.99-1.04	.358
Hispanic	1.14	1.05-1.23	.002
Other ^a	0.77	0.74-0.81	< .001
White	Reference		
Insurance status			
Medicare	1.38	1.33-1.42	< .001
Medicaid	1.68	1.58-1.78	< .001
Other ^b	1.28	1.19-1.39	< .001
Commercial	Reference		

^aThe race/ethnicity category "other" includes American Indians, Alaskan natives, Asians, Hawaiians or Pacific Islanders, and those with multiple or unknown races.

^bThe insurance category "other" includes those receiving charity care, self-pay patients, and those whose insurance status is unknown.

Note. CI, confidence interval.

ages and time intervals between tests for individual components of MetS (blood pressure, blood glucose, and lipids) could result in missed opportunities to identify patients with this condition.

This research has a few limitations. Collection of study data from an EMR system could have affected these results due to potential mistakes in data entry. Carolinas HealthCare System's facilities are mainly in Western North Carolina; therefore, the MetS prevalence proportions observed in this study may not be generalized to the entire state. We excluded cases without data for all 5 MetS parameters, which reduced the size of the base population and could have biased our results. The direction and magnitude of such bias is difficult to predict. For example, some healthier and/or younger patients without MetS may not regularly visit health care providers and/or have routine blood work performed. Such patients would have been excluded from our study, thus increasing the MetS prevalence estimates. On the other hand, some patients with MetS might have had only a few laboratory values measured during the study year. These patients also would have been excluded from our analysis, decreasing the MetS prevalence proportions. The use of surrogate criteria to examine the presence of MetS could have underestimated the actual MetS prevalence. Finally, we determined the insurance status of the study cohort based on the primary payer listed on the most recent billing record

prior to collection of laboratory measurements. Using this process, we could not take into account changes in insurance status or the presence of multiple insurance policies. The findings of the study should be interpreted in light of these limitations.

Conclusion

Progress towards reducing the impact of diabetes and cardiovascular disease in North Carolina requires attention to risk factors such as MetS. We found the prevalence of MetS to be 22.5% in an adult population receiving care in a large integrated health care system. For individual MetS criteria, the prevalence was highest for elevated blood pressure (60.9%), followed by elevated BMI (54.1%). Groups of patients with the highest estimated odds of having MetS included individuals aged 50-59 years, women, Hispanics, and those with Medicaid. These results provide some of the most current region-specific data to inform clinical practice and health care policy. Future policy should address both strategies to better screen for MetS risk factors and interventions aimed at reducing the prevalence of MetS. NCMJ

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